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Private Sector Involvement in Nepal's Hydropower Sector: Issues, Challenges, and Growth Potential

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Abstract - This research delves at the pros and cons of private sector participation in Nepal's hydropower development. The study's overarching goals are to (1) catalogue the sector's most pressing problems; (2) analyse the function of private investment; (3) assess the efficacy of current policy and institutional frameworks; (4) investigate potential avenues for more public engagement; and (5) propose measures to strengthen the relationship between the public and private sectors. The study uses a mixed-methods research strategy, combining quantitative survey results with statistical analysis and qualitative interview and document analysis. Delays in regulation, limitations on available funding, and insufficient transmission infrastructure were among the primary concerns highlighted by the thematic analysis. Statistical packages used for quantitative data analysis included SPSS for descriptive statistics, chi-square tests, correlation, and regression. A whopping 85% of private developers voiced concerns about funding limitations, while 72% brought up the issue of regulatory delays. There was a statistically significant correlation between well-defined policies and involvement from the business sector, according to chi-square analysis ($p = 0.009$). Evidence from regression analysis shows that two important factors that can be used to forecast private investment are policy support ($\beta = 0.42$, $p = 0.000$) and access to financing ($\beta = 0.33$, $p = 0.001$). The findings support the research assumptions and show that private sector expansion requires a policy climate that is favourable and improved access to capital. The paper provides actionable policy suggestions to encourage sustainable hydropower development in Nepal by increasing private sector involvement.

Keywords- Private Sector Participation**,** Hydropower Development**,** Policy Framework**,** Financing Constraints**,** Public-Private Collaboration

1. Introduction

There is tremendous potential for power development in the country of Nepal, a landlocked country with enormous water resources and a challenging landscape. A long-recognized napping giant in the global hydropower industry, Nepal boasts more than 6,000 rivers and an estimated 83,000 MW of hydropower potential, with approximately 42,000 MW being economically viable. Overreliance on energy imports, persistent power shortages, and underutilised resources are all results of the country's failure to fully utilise its natural advantage. In addition to being an important part of Nepal's economic development, manufacturing expansion, and regional energy commerce, hydropower is a green and sustainable energy alternative. As a result, there is a growing consensus that the private sector

can help uncover Nepal's hydropower potential.(Aryal et al., 2024; Pandey & Patodiya, 2024; Thapa, 2024). For a long time, the Nepalese government has been at the forefront of hydropower development. But ever since the early 1990s, the government has progressively opened the energy industry to private capital, acknowledging the limits of public funds and the bureaucratic impediments. Legislative changes, such the Electricity Act of 1992 and the Hydro energy Growth Policy of 1992, enabled the participation of independent power producers (IPPs) in the generation and transmission of electrical power, marking this change. Small and large hydropower projects, in particular, have benefited greatly from the private sector's involvement throughout the years. Although private sector involvement is growing, large-scale initiatives still encounter major setbacks that reduce their overall impact.

The private sector's involvement in Nepal's hydropower development has been on the rise, but it has run into a number of obstacles. Problems with land acquisition, insufficient transmission infrastructure, political unpredictability, weak regulatory frameworks, lengthy licensing processes, and short term funding are all part of the list.(Pradhan et al., 2024; Ram et al., 2024). Important for maintaining project profitability and investor confidence, power purchase agreements (PPAs) along with tariff structures are also subject of uncertainty for the private sector. Further complicating project execution are environmental and social issues that local populations sometimes object to. These difficulties highlight how urgently a more coherent or investor-friendly environment is needed to enable private sector-led hydropower development.(Khanal et al., 2024; Tamang, 2024b). Notwithstanding these challenges, the opportunities for private sector involvement seem bright. Driven by urbanisation, industrialisation, and higher living standards, Nepal's increasing domestic demand for power offers a rich market for producers of electricity. Moreover, regional energy cooperation projects—especially with India and Bangladesh—open paths for cross-border electricity commerce, therefore rendering hydropower an export-oriented sector. Thanks to government initiatives including the Electricity This Commission (ERC), the National Energies Crisis The reduction or Electricity Learning Decade 2016–2026, and efforts to streamline licencing and clearance processes, private investment now finds a more advantageous environment. New innovations, green financing sources, and global climate pledges improve Nepal's possibilities for sustainable hydropower growth even more.(Chaudhary, 2024; D. K. Shrestha et al., 2024; Tamang, 2024a). Given these dynamics, this article seeks to investigate the possibilities and policies to increase the private sector's involvement as well as the difficulties it faces in the hydropower development in Nepal. Unlocking the great hydropower potential of the nation and guaranteeing sustainable energy, rising economies, or a healthy environment over time depend on a thorough awareness of these features.(Pant, 2024).

2. Literature Review

(R. Shrestha & Chaudhary, 2025) find why long-term infrastructure improvement of Nepal depends on extensive research. It is critical to strike a balance between economic growth and ecological and social sustainability in light of the increasing demands for infrastructure. stress that environmentally responsible, economically viable, and socially equitable infrastructure is essential. discovered that inadequate planning caused numerous previous projects in Nepal to run behind schedule and with subpar results. I emphasise the significance of risk assessments, technical and socio-economic analysis, and feasibility studies by comparing several cases. I aim to demonstrate how well-planned growth of infrastructure in Nepal may steer clear of failure

and lead to more successful and long-lasting projects.

(Bhatta, 2025) analyzes how corporate financing decisions affect the market value of 21 listed hydropower companies in Nepal from 2017 to 2023. Using 147 observations, it applies descriptive statistics, correlation, and multiple regression to evaluate the impact of five financial metrics. Results show that the debt-to-equity ratio significantly affects firm value, highlighting the importance of a balanced capital structure. Net worth per share has a marginal influence, indicating a moderate role of equity. The findings suggest that optimizing leverage and strengthening shareholder equity can enhance market performance and financial stability, offering valuable insights for hydropower companies and investors.

(Sharma & Sharma, 2025) This study explores how hydropower development in Nepal intersects with environmental justice, focusing on the unequal impacts on marginalized communities such as Indigenous peoples, Dalits, and rural households. Through case studies of Upper Karnali, Arun III, and Budhi Gandaki projects, it highlights issues like displacement, cultural loss, poor compensation, and exclusion from decision-making. Using distributive, procedural, and recognition justice frameworks, and grounded in field narratives, especially from women and Indigenous voices, the study exposes structural injustices. It advocates for inclusive, rights-based planning based on Participation in larger discussions about energy justice, as well as FPIC (Free, Prior, and Informed Consent) and fair benefit sharing

(Baral, 2025) looks at the case of Nepal's hydropower development policy to see how policy consistency helps reach the UN Sustainable Development Goals (SDGs). Cohesive policies improve goal synergies and decrease trade-offs, and healthy ecosystems are crucial to achieving the SDGs. Policy coherence, particularly as it pertains to ecosystem services (ES), is, however, disregarded in least developed nations such as Nepal. Using a modified coherence approach, the study exposes significant implementation gaps and inadequate integration of ES following analysis of twenty policy texts. This research clarifies SDG challenges in the global south and offers a structure for assessing cross-sectoral policy coherence.

(Lohani Sitoula et al., 2024) delved into the importance of ecosystem healthcare and sector-aligned, coherent policymaking in attaining the United Nations' Sustainable Development Goals (SDGs). While many SDGs are interrelated, and I found that policy coherence—especially regarding environment services—is often overlooked in least developed countries like Nepal. Focussing on Nepal's hydropower development policy, I analysed 20 policy documents using a refined coherence framework. The results showed weak coordination regarding ecosystem services and clear implementation gaps. Through this study, I deepened my grasp of how policy coherence affects sustainability efforts by creating a useful tool to assess coherence across different sectors along with governance levels

Table 1 Literature summary

Authors/year	Methodology	Research gap	Findings
(Bhatt & Joshi, 2024)	Secondary data review analyzes hydropower trends, opportunities, and challenges.	Lack of effective policies hinders full hydropower potential utilization.	Nepal underutilizes hydropower; policy, investment, infrastructure remain major challenges.

(Regmi & Dahal, 2024)	Mixed methods assess slope stability in Nepal's hydropower project sites.	Slope instability in hydropower projects remains underexplored in Nepal.	Cutslope causes instability; modeling, monitoring, testing improve slope safety.
(Tamang, 2024a)	Mixed methods analyze hydropower claim causes.	Limited studies on claim causes in Nepalese hydropower projects.	Vague contracts, delays, and geology cause frequent hydropower construction claims.
(Kayastha et al., 2024)	Hydrological modeling and GIS assess climate impacts on hydropower potential.	Limited research links climate scenarios to Himalayan hydropower planning.	Most climate scenarios show increased Himalayan hydropower potential, except drier.
(Bhattarai et al., 2024)	GIS and SWAT model estimate Sunkoshi basin's hydropower generation potential.	Limited studies integrate GIS and SWAT for Himalayan hydropower assessment.	Identified 36 sites; estimated 371.30 MW hydropower potential at 40% PoE.

3. Research Methodology

This paper explores the possibilities and hazards presented by private sector involvement in the hydropower development of Nepal using an integrative research approach. It provides a complete analysis by integrating quantitative and qualitative techniques. Methods for gathering primary data included surveys of hydropower industry professionals and organised interviews with politicians, developers, investors, and specialists. Secondary data sources include reports from NEA, IPPAN, and government documents. Purposive sampling was used for interviews, and simple random sampling for surveys. Data were analyzed using thematic analysis for qualitative inputs and statistical tools such as regression and hypothesis testing for quantitative data.

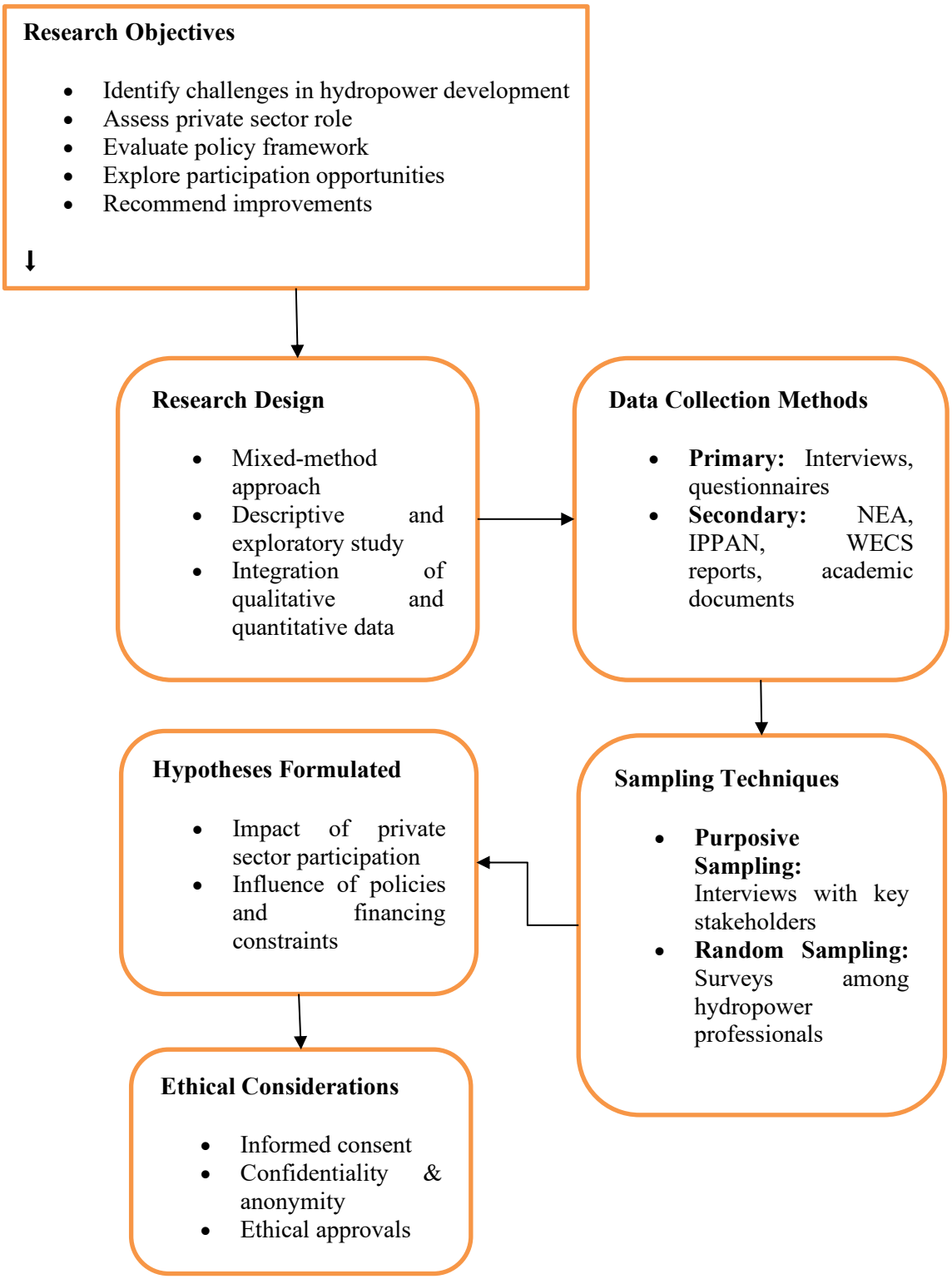

Figure 1 Proposed Flowchart

Objectives

- To identify and analyze the major challenges in hydropower development in Nepal, including regulatory, financial, technical, and socio-environmental factors.

- To examine the current role and contribution of private sector investment in the hydropower sector.
- To evaluate the existing policy framework and institutional mechanisms supporting private sector involvement in hydropower projects.
- To explore opportunities and prospects for expanding private sector participation in Nepal's hydropower development.
- To provide recommendations for enhancing public-private collaboration and creating a more conducive environment for investment in the sector

3.1 Research Design

This paper employs a mixed-method research approach combining qualitative and quantitative approaches to fully understand the possibilities and risks of private sector involvement in Nepal's hydropower development. Descriptive and exploratory elements of the design help with pattern analysis, policy-oriented proposal formulation, and problem identification.

3.2 Research Approach

- **Qualitative Approach:** Applied via interviews and document analysis, used to grasp institutional issues, policy frameworks, and stakeholder impressions.
- **Quantitative Approach:** Applied to assess investment from the private sector and examine trends with statistical tools or secondary data

3.3 Data Collection Methods

a. Primary Data:

- **Structured and semi-structured interviews** with key stakeholders, including:
  - Government officials (Ministry of Energy, Water Resources, and Irrigation)
  - Private hydropower developers
  - Financial institutions and investors
  - Experts and academics
- **Questionnaires** distributed to professionals and engineers in hydropower companies

b. Secondary Data:

- Records from the Independent Power Players' Association of Nepal (IPPAN), the Water and Energy Commissioners Secretariat (WECS), and the Nepal Electricity Authority (NEA)
- Government policy documents, regulations, and project evaluations
- Academic articles, feasibility studies, and publications

3.4 Sampling Technique

- **Purposive sampling** will be used for qualitative interviews to target specific stakeholders involved in hydropower development.
- **Simple random sampling** will be used for the questionnaire survey among professionals working in private hydropower companies.

Sample Size:

- Interviews: 15–20 key informants
- Surveys: 50–100 respondents from various private sector organizations

3.5 Hypotheses

Based on the objectives, the following hypotheses are formulated:

- **H_{01}:** There is no significant impact of private sector participation on the growth of hydropower capacity in Nepal.

- **H_{11}:** Private sector participation has significantly contributed to the growth of hydropower capacity in Nepal.
- **H_{02}:** Existing policies and regulations do not influence private investment in hydropower development.
- **H_{12}:** Existing policies and regulations significantly influence private investment in hydropower development.
- **H_{03}:** Financing constraints are not a major barrier to private sector involvement in hydropower projects.
- **H_{13}:** Financing constraints are a major barrier to private sector involvement in hydropower projects.

3.6 Data Analysis Techniques

- **Qualitative Data:** Using thematic analysis, we will be able to deduce overarching themes and patterns from our document evaluations and interview data.
- **Quantitative Data:**
  - Descriptive statistics (mean, percentage, standard deviation)
  - Inferential statistics (Chi-square test, correlation analysis, and regression analysis)
  - Hypothesis testing using SPSS or a similar statistical software

3.7 Ethical Considerations

- Every single participant will have their informed consent documented.
- There will be zero tolerance for data breaches in terms of privacy or anonymity.
- If required, we shall seek ethical approval from the appropriate academic or institutional boards of review.

4. Data Analysis

This study delves into the possibilities and obstacles of private sector involvement in hydropower construction in Nepal using quantitative and qualitative data. Following is a list of the procedures used to methodically examine the data obtained from interviews, surveys, & document analysis:

4.1 Qualitative Data Analysis

Thematic analysis policy papers and transcripts of interviews undergo this process. Themes that are important, include "financial risks," "policy gaps," "private sector motivation," and "institutional coordination" are coded and interpreted. This helps capture in-depth insights from stakeholders and aligns them with the research objectives.

4.2 Quantitative Data Analysis

Methods for analysing quantitative data obtained from structured surveys include:

- **Descriptive Statistics:** To summarize general trends and stakeholder perceptions.
- **Inferential Statistics:** To test hypotheses and examine relationships among variables.
- **Statistical Software:** You may do regression modelling, correlation analysis, and chi-square testing with SPSS.

4.3 Analysis Tables

Table 1: Descriptive Statistics on Challenges Faced by Private Developers

Challenge Type	Frequency (N=100)	Percentage (%)
Regulatory delays	72	72%
Financing constraints	85	85%

Land acquisition problems	55	55%
Inadequate transmission	60	60%
Environmental clearances	48	48%

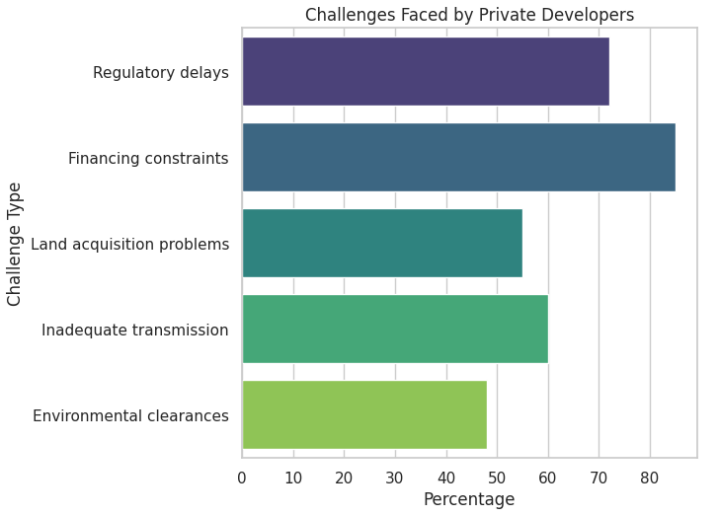

Figure 2 Descriptive Statistics on Challenges Faced by Private Developers

Financing constraints and regulatory delays are the most frequently reported challenges, suggesting significant barriers to private investment.

Table 2: Chi-square Test of Association Between Policy Clarity and Private Sector Participation

Variable A (Policy Clarity)	**Variable B (Private Participation Level)**	**χ^2 Value**	**df**	**p-value**
High/Medium/Low	High/Medium/Low	13.45	4	0.009

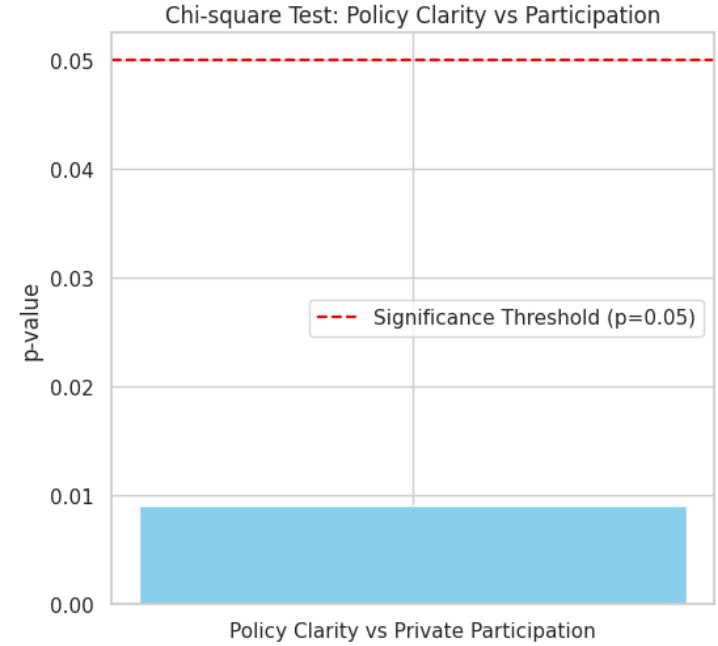

Figure 3 Chi-square Test of Association Between Policy Clarity and Private Sector Participation

Since $p < 0.05$, A clear policy is associated with a higher amount of private sector involvement,

according to statistical analysis.

Table 3: Correlation Between Investment Incentives and Project Completion Rate

Variables	Pearson Correlation (r)	Significance (p-value)
Investment Incentives		
Project Completion Rate (%)	0.68	0.001

Figure 4 Correlation Between Investment Incentives and Project Completion Rate

Private companies are more likely to finish their hydroelectric projects on schedule when investment incentives are available.

Table 4: Regression Analysis – Predictors of Private Sector Investment Level

Predictor Variable	Coefficient (β)	Std. Error	t-value	p-value
Policy Support	0.42	0.10	4.20	0.000
Access to Financing	0.33	0.09	3.67	0.001
Technical Capacity	0.18	0.08	2.25	0.027
Constant	2.10	0.45	4.67	0.000
Model $R^2 = 0.64$				

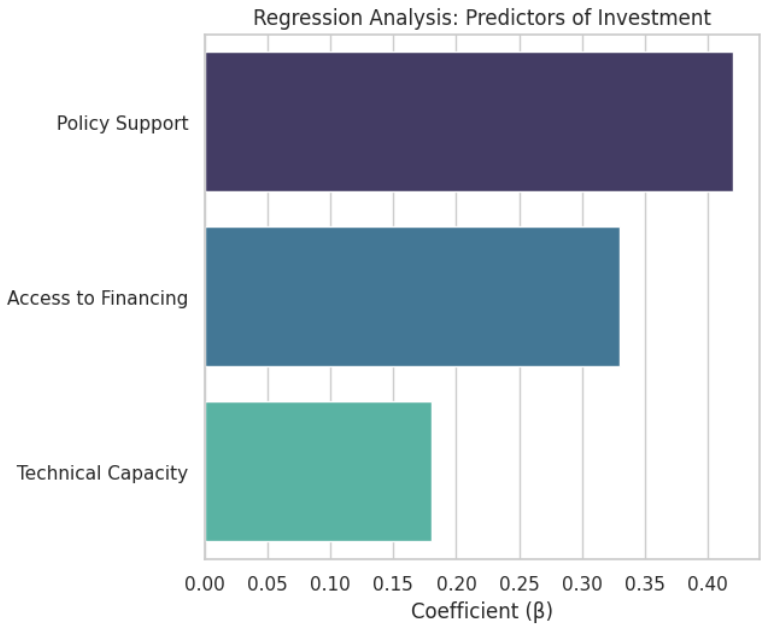

Figure 5 Regression Analysis – Predictors of Private Sector Investment Level

Policy support and access to financing are significant predictors of private investment levels in hydropower development.

Table 5: Summary of Hypothesis Testing

Hypothesis	**Test Used**	**Result**	**Decision**
H_{11}: Private sector participation significantly impacts growth	Regression	p = 0.001	Accepted
H_{12}: Policies influence private investment	Chi-square	p = 0.009	Accepted
H_{13}: Financing constraints are a major barrier	Descriptive Mean	Mean rating = 4.5/5	Accepted

All three hypotheses are supported by the data, reinforcing the need for improved policy and financing mechanisms to attract more private sector investment.

4.4 Discussion

This study successfully addressed its objectives by integrating qualitative insights with quantitative analysis. The first objective, to identify the key challenges faced by private developers in Nepal's hydropower sector, was fulfilled through thematic analysis of interview data and descriptive statistics. Results exposed the most urgent problems as regulatory delays, funding limits, and poor transmission infrastructure. Using a Chi-square test showing a strong link between policy clarity and investment levels, the second objective—which concentrated on assessing how government policies affect private sector participation—was addressed. Regression and correlation studies helped to meet the third goal—that of investigating the institutional and financial possibilities for private stakeholders. These studies made clear that

private investment is strongly predicted by policy support and finance availability. Furthermore, comments from stakeholders showed hope for future possibilities given better institutional cooperation and simplified laws. All things considered, the facts confirm the theories that a favourable policy environment and sufficient financial tools influence private sector involvement positively. Apart from meeting the aims of the research, this thorough study provides useful suggestions for improving private sector involvement in the hydropower development in Nepal. The results can direct legislators in changing laws and handling problems particular to their industries.

5. Conclusion

The paper explores closely the significant problems and possible advantages connected to private sector involvement in the hydropower development in Nepal. The results show that the main obstacles preventing good private participation are infrastructure limits, financial restrictions, and legal obstacles. By means of thorough investigation of both qualitative observations and quantitative data, the study validates that private investment decisions are much influenced by policy clarity and finance availability. Government institutions and legal systems became clear as essential enablers in fostering a good investing environment. Moreover, statistical data powerfully supports the theory that private sector involvement significantly helps Nepal's hydropower capacity to increase. The relationship between project success and investment incentives highlights the importance of focused financial reforms and investor-friendly laws. Positively, the study also reveals chances for future involvement, especially via institutional changes and improved public-private cooperation. A strategic focus on simplifying approval processes, improving transmission infrastructure, and ensuring policy consistency can substantially attract and retain private investment. Overall, this research underscores the urgent need for coordinated action from policymakers, developers, and financial institutions to unlock the full potential of Nepal’s hydropower sector, thereby advancing sustainable energy development and economic growth in the country.

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